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SUPERFUND RECORDS

BIG RIVER SURVEY
SOUTHEASTERN, MISSOURI

OCTOBER 27, 1978

by

U S ENVIRONMENTAL PROTECTION AGENCY
Region VII
Surveillance and Analysis Division

SITE	BIG RIVER MINE
ID#	MOD981126899
BREAK	16
OTHER	10-27-78

OTCR

INTRODUCTION

During the summers of 1962 and 1963, the Missouri Conservation Commission, the Missouri Geological Survey, and the United States Geological Survey conducted a cooperative study of surface water quality in the Meramec River basin in Southeastern, Missouri. During this investigation, the Meramec River, and many of its tributaries were studied. Many water quality problems were identified with some receiving supplemental work during the study period. One problem area which was identified but did not receive additional work, was the reach of the Big River between the City of Leadwood and Washington State Park (see figure 1). The land area in the vicinity of this section of the Big River has been extensively mined for lead and zinc since the early 1800's, and more recently for barium. Mine tailings are the prevalent stream bottom materials at several points along the affected reach especially around the cities of Leadwood, Flat River, Desloge, and Bonne Terre.

The cooperative survey report revealed that this 40-mile stream reach had been degraded as evidenced by poor species diversity while the water chemistry data proved inconclusive. The report recommended that further research was needed to determine the effect of mine tailings on aquatic organisms and water quality in the Big River.

In January 1977, the Missouri Department of Natural Resources (MDNR) requested this agency to conduct a study on the reach of the Big River between Leadwood and Washington State Park for the purpose of determining

- 1) If the affected stretch had extended downstream,
- 2) The validity of the hypothesis that degradation was caused by substrate contamination, and
- 3) The overall impact of seepage and runoff on water quality

In response to this request, Surveillance and Analysis Division (SVAN) personnel conducted a two phase study in order to answer the questions raised by the MDNR. The first phase, (reconnaissance) was a preliminary study designed to familiarize investigative personnel with the project area and to gather data for use in planning and directing the second (intensive) phase of the investigation. This report presents the results of those investigations.

INVESTIGATIVE PERSONNEL

Reconnaissance Phase

Personnel	Steven W Sisk
Title	Hydrologist (Project Leader)
Personnel	Thomas Lorenz
Title	Aquatic Biologist
Date	May 30 through June 3, 1977

Intensive Phase

Personnel	Bruce Littell
Title	Aquatic Biologist
Personnel	Leotis Mosby
Title	Aquatic Biologist
Date	August 23 through September 26, 1977

SUMMARY OF STUDY ACTIVITIES

Reconnaissance Phase - Procedures

The objectives of the reconnaissance were to examine the local geology, old mining areas, and the affected reach of the Big River. Lead and zinc were mined from the Cambrian Bonne Terre Formation most extensively in the vicinity of Leadwood, Flat River, Desloge and Bonne Terre. Ore processing and refining facilities had once operated in this region. Virtual mountains of tailings dominate the landscape in the vicinity of these communities. Many of these piles are situated adjacent to the Big River channel (see figure 2). Over the years, large quantities of the sand and gravel sized tailings have been washed into the river by rainfall runoff. These materials have apparently resulted in the stream degradation noted during the cooperative survey of the early 1960's. The main issue to be resolved during the current studies was whether degradation was the result of a physical or chemical problem created by the tailings.

Ten stations along the study reach of the Big River were selected for biological and geological characterizations and water sample collection. In addition, bottom sediment samples from two of these stations were analyzed biologically for leachates toxic to aquatic life. Several of these stations had been previously established during the earlier cooperative survey. The station locations and previous survey designations are shown in Figure 3 and are described as follows.

<u>Station Number</u>	<u>Location Description</u>
BR-1	Big River beneath the Highway 8 bridge located approximately 2 5 miles east of Leadwood (Cooperative Survey Station MBI-2)
BR-2	Big river just below small impoundment structure on the north side of Leadwood SW $\frac{1}{4}$,SW $\frac{1}{4}$, Section 34, T37N, R4E
BR-2 5	Big River just north of Desloge city dump at low water bridge SE $\frac{1}{4}$,NE $\frac{1}{4}$, Section 35,T37N, R4E
BR-3	Big River beneath Old Bonne Terre Road bridge approximately 0 5 miles north of Desloge SE $\frac{1}{4}$ NE $\frac{1}{4}$, Section 25, T37N, R4E (Cooperative Survey Station MBI-2A)
BR-4	Big River beneath County road K bridge approximat 2 miles east of Bonne Terre (Cooperative Survey Station MBI-3)
BR-5	Big River beneath County Road E bridge approximat 3 miles north of Bonne Terre (Cooperative Survey Station MBI-4), SW $\frac{1}{4}$,NE $\frac{1}{4}$,Section 34,T38N,R4E
BR-6	Big River at west end of Dickman Road NE $\frac{1}{4}$,NE $\frac{1}{4}$, Section 19, T38N, R4E
BR-7	Big River near bend in county road approximately 1 mile south of Blackwell Above Mill Creek confluence NW $\frac{1}{4}$,NW $\frac{1}{4}$, Section 8, T38N, R4E
BR-8	Big River upstream from County Road CC bridge at Blackwell NE $\frac{1}{4}$,SE $\frac{1}{4}$,Section 6, T38N, R4E
BR-9	Big River at Highway 21 bridge just east of Washington State Park (State Survey Station MBI-5)

The station descriptions just presented describe a major identifiable feature along a short particular stream reach examined by field personnel The geological and biological characteristics of the stream bottom along these reaches were noted and recorded A brief summary of the significant observations made at each station is presented in the following paragraphs

Station BR-1

Stream bottom materials are completely natural in origin with no evidence of mine tailings. Materials included "salt and pepper" sandstone, quartz sand, pebble and cobble size carbonate rocks, some with vugs and large crystals. The biological diversity was moderate with a low standing crop of benthic macroinvertebrates (Macrobenthos). This condition may be related to season. Macrobenthos populations included three kinds of mayflies, riffle beetles, crayfish, snails, three species of fresh water clams, and three kinds of midges. Vertebrates noted were darters, minnows, bluegill, suckers and largemouth bass.

Station BR-2

Stream bottom materials contain significant amounts of sand to pebble size mine tailings and pebble sized brown chert fragments. Naturally derived rock fragments still predominate. A high diversity of Macrobenthos was observed. The area is used for sport fishing. Macrobenthos populations included three species of mayflies, stoneflies, snails, freshwater clams, two species of caddisflies, numerous kinds of midges, dobsonflies and horseflies. Fish were present in pooled areas.

Station BR-2 5

Stream bottom materials consisted of virtually all mine tailings with few cobbles of "salt and pepper" sandstone. Tailings present as two distinct sizes, sand and pebble. Mixed with pebble sized tailings were coal and cinder fragments. Very little quartz sand was observed. A moderate diversity of stream biota was observed. Macrobenthos populations included two species of mayflies, dragonflies, damselflies, scuds, stoneflies and midges, however, density was very sparse. Only a few small fish were observed.

Station BR-3

Stream bottom materials are nearly all mine tailings and brown chert fragments. Tailings are mixed but are still present as two distinct sizes, sand and pebble. The stream biota exhibited low diversity and sparse populations. Macrobenthos population included backswimmers, stoneflies and midges. Vertebrates observed were spinny softshell turtles, darters and bass.

Station BR-4

Stream bottom materials comprised of naturally derived rock fragments and quartz sand in addition to recognizable mine tailings. The stream biota exhibited low diversity at this station. Macrobenthos observed were predaceous diving beetles, midges, and damselflies. Vertebrates noted were sunfish, bass, fingerlings and darters.

Station BR-5

Stream bottom materials comprised primarily of naturally derived quartz sand, brown chert pebbles and cobbles, and large pebble to cobble sized dolomite fragments. Tailings fraction present but not apparent. The diversity of aquatic organisms was moderate at this station. Macroenthos included three species of mayflies, stoneflies, caddisflies, dobson flies, riffle beetles and midges. Vertebrates noted were minnows and darters.

Station BR-6

Stream Bottom materials nearly all of natural origin. Materials comprised of quartz sand, pebble and cobble sized chert with druse and red clay in vugs. Black pea sized cinders were found in shallow pools. Aquatic organism diversity was moderate. Macroenthos included two species of mayflies, caddisflies, midges, predaceous diving beetles, crayfish and stoneflies. The only vertebrates noted were minnows.

Station BR-7

Stream bottom materials are nearly all of natural origin. Materials comprised of quartz sand, chert with druse filled vugs, and brown chert pebbles and cobbles. Black pea sized cinders locally abundant on sandbars. Aquatic organism diversity was moderate. Community structure the same as noted at BR-6, however, the total biomass was low.

Station BR-8

Stream bottom materials are nearly all of natural origin. Materials comprised of quartz sand, pebble to cobble-sized chert with druse lined and red clay filled vugs, and sand size pieces of cinder. Very little evidence of mine tailings. The aquatic population diversity was higher than at BR-7. Macroenthos included three species of mayflies, caddisflies, crayfish, stoneflies, predaceous diving beetles, riffle beetles and midges. The only vertebrates noted were minnows and darters.

Station BR-9

Stream bottom materials are virtually all of natural origin. Materials comprised of chert and dolomite pebbles and cobbles, quartz sand with scattered pieces of cinders. The aquatic population diversity was high at this station. The same species noted at BR-8 were present here, but the density was greater.

Water samples were collected at each of the stream stations on June 2, 1977. The analytical results derived from these samples are presented in Table 1. In addition to the stream samples, two other sample sets were collected in order to provide predictive data regarding tailings pile runoff and groundwater seepage contributions to Big River.

In the southwestern section of Leadwood, a runoff collection pond had been constructed on the north side of a large tailings pile (See figure 2). A local resident reported that the pond had been stocked with fish and that several large ones had recently been caught. A sample of the runoff pond water was collected in order to provide data relating to the potential quality of runoff. Due to the extended contact time between the pond water and the tailings, it is presumed that the sample would represent a worst case condition. The sample analytical data is presented on table 1.

Near the center of Bonne Terre, an old lead mine has been reopened as a tourist attraction. The mine had seven operating levels before it was closed and was several hundred feet deep. Since the mine closed, the five lower levels were flooded by groundwater seepage. A sample of the mine water was collected in order to provide data relating to the potential quality of groundwater seepage into the Big River from old mines. The sample analytical data is also presented on Table 1.

As previously indicated, two sediment samples were collected for a leachate toxicity evaluation. Station BR-1 was selected as one of the sediment sampling stations because of its location upstream from the heavily mined areas and the complete absence of tailings in the sediment. Station BR-4 was selected for the second sediment sampling point because the sediment reflected a mix of tailings and naturally derived materials, yet "degradation" had been noted both up and downstream from this location. The sediment samples were taken to the EPA Regional Laboratory for Toxic evaluation. Each sediment sample was washed three times with tap water to remove the detritus and rinsed twice with deionized water. Afterwards, each sample was placed in a four-liter glass beaker and filled to the 3500 ml mark with aerated synthesized hard water. One-half of the volume in each beaker was occupied by substrate and the other half with water. Ten acclimated adult water fleas (Daphnia magna) were placed in each beaker and left for 72 hours.

Six of the nine adult water fleas recovered from the station one sample were still alive after the 72-hour test period. Two living juvenile water fleas were also observed. All 10 adult water fleas were recovered alive from the station four sample along with six juveniles.

These results suggest that neither of the two substrates contain readily leachable toxic materials which under normal circumstances would cause acute mortality to aquatic organisms. The death of the four adult water fleas in the Station BR-1 sample was probably caused by their entrapment in the interstitial spaces of the coarse sediment restricting their necessary movement.

Reconnaissance Phase - Findings

- 1 The geological and biological characterizations of the Big River stream bottom revealed significant deposits of mine tailings and depressed aquatic population densities in the upper reaches of the study segment.
- 2 The stream water chemistry data suggest no obvious toxic pollutant contamination problem. However, the low ammonia and nitrate nitrogen concentrations did suggest the possibility of a nutrient limited system. The stream condition was apparently similar to that described by the cooperative survey investigators.
- 3 The leachate toxicity evaluation conducted on two sediment samples yielded negative results suggesting that the bottom materials are not chemically toxic to aquatic organisms.
- 4 The suspected cause of the observed degradation is shifting stream bottom materials. The instability of the sediment is attributed to the large amounts of uniformly sized mine tailings introduced along the upper parts of the study segment.

Intensive Phase - Procedures

The objectives of the intensive phase were to obtain additional data needed to answer the questions posed by the MDNR in the study request letter. Study emphasis was placed on determining if the shifting bottom sediments were responsible for the observed degradation, and if limited soluble nutrients were contributing to the problem.

The intensive phase study plan was comprised of four elements. The first element involved the placement of artificial substrates along the affected reach for two reasons:

- 1) To determine whether or not the numbers and species of aquatic organisms would increase per unit area if given a different kind of substrate on which to colonize, and,
- 2) To determine whether or not the river itself would support aquatic life at each station if the variability of the river substrate were eliminated.

The second element consisted of a more thorough biological characterization of the bottom dwelling organisms at stations BR-5 and 9 in order to assess the relative natural productivity and species diversity. A comparison of similar data from the cooperative survey report was made to determine if the affected reach had extended downstream. The third element was a series of algal assays conducted on water samples from stations BR-1, -3 and -5.

The assays were used to determine whether or not the water samples were nutrient limited. The fourth and final element was the collection of water samples at stations BR-1, 3 and 5. The samples were collected in order to characterize the water used in the algal assays and for comparison with the data obtained during the reconnaissance.

On August 23, 1977, two periphytometers and three multiplate samplers (For Macrobenthos) were situated at each of the following stations: BR-1, BR-2, 5, BR-3, BR-4, BR-5, and BR-6. On the same day, qualitative and quantitative macrobenthos and qualitative phytoperiphyton (attached algae) grab samples were collected from riffle areas at BR-5 and BR-9. The following day, water samples were collected at BR-1, BR-3, and BR-5 for chemical analysis and algal assays.

Sixteen days after the initial set-up, three glass slides were removed from one of the two periphytometers at each station (except at BR-1), placed in a preservative and returned to the laboratory for analysis. All five artificial substrates were missing from BR-1 and had to be replaced. Thirty-three days after the initial set-up, the multiplate samplers were recovered from all six stations, preserved, and returned to the laboratory. Included in this sample collection were three glass slides from a periphytometer at BR-1.

The findings of each element of the intensive phase are discussed individually in the following paragraphs.

Element 1

The phytoperiphyton from the artificial substrates gave no indication of dissolved metal inhibition. In fact, there was a progressive increase in productivity (cell numbers) between BR-1 and BR-4 with a gradual decrease between BR-4 and BR-6 (Table 2). Diatoms made up greater than 75 percent of the phytoperiphyton from each station with the exception of BR-2, 5 (61 percent). Only one of the four most prominent diatoms at each station

was an indicator of eutrophic (nutrient enriched) waters. Curiously, Mougeotia, a filamentous green alga, comprised an unusually large portion (36 percent) of the phytoplankton at BR-2. Nitzschia palea, an obligate nitrogen heterotroph, made up greater than half of the diatoms at BR-4. This, plus the absence of a predominant nitrogen heterotroph at BR-3 indicated a source of organic pollution into the river between these two stations.

Macrobenthos diversity data from the multiple samplers indicated little difference between stations BR-1 through BR-6 (Table 3). The number of individuals, however, more than doubled between BR-2 and BR-3, and remained relatively high from BR-4 through BR-6. Station BR-1 had the fewest taxa and numbers, probably because of the shorter (two week) exposure period.

Evidence of a change in water quality by runoff and/or point-source discharges was demonstrated by the phytoplankton. The high number of organic pollution-indicating algae at BR-4 and BR-5 indicated one or more sources of organic loading upstream from both stations. One source may be the Flat River Sewage Treatment Plant (STP) which discharges into the Flat River. The Flat River confluence with the Big River is located between BR-3 and BR-4. Another source may be the Bonne Terre STP which discharges into Turkey Creek. Turkey Creek empties into Big River between BR-4 and BR-5.

Element 2

Based on the diversity (number of taxa) and the number of individual macrobenthos found in the substrates of BR-5 (mine tailings) and BR-9 (natural substrate), the latter proved to be a more suitable habitat. Nearly 15 times as many organisms and twice the number of taxa were collected from two square feet at BR-9 as compared to the same area at BR-5 (Table 4). Although the BR-5 quantitative sample suggested a substrate capable of supporting few taxa, the qualitative sample indicated it does support a greater variety. These data suggest that the population densities are low, rather than the diversity, as was indicated by the earlier cooperative survey.

Rock scrapings from BR-5 and BR-9 substrates were preserved and examined for the relative abundance of phytoplankton. Phytoplankton, the predominant primary producer in shallow rivers, is an excellent indicator of water quality. Waters are considered "healthy", or at least free from excessive amounts of decomposable organic wastes, when diatoms and green algae make up most of the phytoplankton. Diatoms and green algae (mostly diatoms) made up greater than three-fourths of the attached algae.

at BR-5 and BR-9 (Table 5) The BR-5 phytoplankton gave no indication of stress caused by dissolved metals There was, however, evidence of moderate disturbance caused by decomposable organic wastes Forty-seven percent of the BR-5 diatoms were nitrogen heterotrophs (utilize organic nitrogen). In addition, virtually all of the filamentous blue-greens (20 percent of the total phytoplankton) were species of Oscillatoria and Lyngbya, two genera commonly associated with organically enriched waters The attached algae at station BR-9 consisted of fewer organic pollution indicators suggesting this point along the Big River is in a recovery zone

Element 3

The algal assay indicated that the stream waters at BR-1, 3 and 5, although phosphorus limited, were capable of supporting moderate productivity No evidence of toxicity was observed even though the chemical analytical data revealed significant increased lead and zinc concentrations between BR-1 and 3 (Table 6)

Element 4

The water samples collected for the algal assay and chemical analyses were taken following an intense rainfall which occurred during the preceding night A comparison of the analytical data derived from these samples and those collected during the reconnaissance is presented in Table 6 The data from the intensive phase sampling is virtually identical to that obtained during reconnaissance with the exception of the lead concentrations of BR-3 and the nutrient (nitrogen) compounds at all three stations The difference in lead concentrations is not considered to be significant since a dust sized particle of galena (lead ore) in the sample could account for the apparent increase The increased nutrient levels may have been caused by increased wastewater treatment lagoon discharges in response to the rainfall or merely the result of runoff from the adjacent land areas

Intensive Phase - Findings

- 1 Data obtained from the periphytometers and the multiplate samplers indicated that given a more suitable substrate, a significantly higher aquatic population density would develop along the affected reach
- 2 The artificial substrate data also suggested the presence of organic pollutants probably resulting from wastewater treatment plant discharges
- 3 The biological characterization of bottom dwelling organisms indicated depressed population densities along the affected reach (BR-5) and significantly higher densities at the Washington State Park station (BR-9)

4. The algal assay revealed the water to be moderately productive and phosphorus limited at all three stations (BR-1,3, and 5) 5 Stream water quality data was obtained following an intensive rainfall event, however, it was virtually identical to the data obtained during the reconnaissance. Apparently, runoff has little effect on the water quality parameters measured during this investigation.

SUMMARY AND CONCLUSIONS

The first of the three questions raised in the study request letter from the MDNR concerned the possible downstream extension of the degraded reach. The cooperative survey findings for the Washington State Park stream station (BR-9) were very similar to the current findings. Both studies indicate that the zone of marked degradation terminates upstream from station BR-9. It is therefore concluded that the zone has not extended downstream, however, no significant decrease in the extent of the zone was noted.

The second question posed was in regard to the hypothesis that degradation was caused by substrate contamination. The current investigation findings indicate that contamination of the natural substrate by mine tailings is responsible for the observed degradation. The data collected during this study indicate that the contamination is physical rather than chemical in nature. The overabundance of mine tailings in the stream channel create a uniformly sized unstable substrate for the macrobenthos and periphyton community. The stream has sufficient energy to move or shift the tailings until a more natural grain size distribution is achieved. Although the bottom sediment continually moves downstream in response to the river flow, the natural grain size distribution creates a more suitable and stable substrate for aquatic organisms over a larger range of flow conditions. The natural grain size distribution is achieved in the vicinity of Washington State Park. The shifting and mixing of the tailings with the natural sediment occurs continuously. The indication that the degraded reach has approximately the same extent as that observed fifteen years ago suggests a condition of dynamic equilibrium. The implication is that the supply of tailings to the river has been relatively constant over time. The large tailings piles situated adjacent to the river channel are the sources of these materials.

The third question, which was addressed to a very limited extent, concerned the effects of runoff and groundwater seepage in the study area. The analytical data from the tailings pond, groundwater in the old lead mine, and stream water samples, collected during the reconnaissance and intensive phases, suggest that the water quality impact is negligible. However, rainfall runoff is responsible for transporting the mine tailings to the river.

RECOMMENDATIONS

The study data presented in this report point to an influx of materials from old tailings piles as being the source of the degradation problem in the Big River. The recommendation, therefore, is to abate the release of these materials through whatever regulatory avenues are available. If more immediate relief from the problem is desired, then the tailings should be removed from the stream channel where they are present in exceptionally large quantities such as the reach between stations BR-2 and 3.

TABLE I
ANALYTICAL DATA

	BR-2	BR-4	BR-6	BR-7	BR-8	BR-9	MILL CREEK	BONNE TERRE COMMERICAL MINE	VALLEY MINERIAL	SMALL TAILING POND
Temperature (°C)	23	21	22	22	23	23	22	13	25	21
	7 9	8 1	8 0	8 2	8 0	8 2	8 2	8 0	8 9	8 3
Conductivity (UMHOS at 25°C)	390	460	470	460	460	450	460	850	4000	900
Ammonia-N	<0 04	<0 04	<0 04	<0 04	<0 04	<0 04	<0 04	<0 04	0 22	<0 04
Nitrate and Nitrite-N	0 08	0 16	0 04	0 04	0 04	0 07	0 05	0 59	1 18	<0 04
Total sulfate	<10	48	31	19	12	<10	<10	195	1090	500
Barium	130	150	180	170	250	320	1400	90	800	100
Calcium	38	46	48	48	48	48	48	96	530	120
Chloride	<10	<10	<10	<10	<10	<10	<10	<65	<10	<10
Copper	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Lead	23	33	36	70	40	40	15	37	<5	42
Magnesium	26	28	28	28	28	28	28	35	125	68
Nickel	<10	<10	<10	<10	<10	<10	<10	67	<10	18
Potassium	1 1	2 8	1 9	2 2	1 4	7	0	1 3	130	3 3
Sodium	2	7	9	4	3	8	5	7	62	8
Zinc	29	127	37	42	36	37	65	66	22	106

All values, unless otherwise indicated, are expressed as mg/l
* ug/l

TABLE 2

BIG RIVER PHYTO-PERIPHYTON DATA FROM ARTIFICIAL SUBSTRATES

	<u>BR-1</u>	<u>BR-2 5</u>	<u>BR-3</u>	<u>BR-4</u>	<u>BR-5</u>	<u>BR-6</u>
Cells/mm ²	1657	2886	4524	5034	3314	2544

RELATIVE ABUNDANCE

Diatoms	84%	61%	84%	87%	86%	78%
Filamentous Greens	3%	36%	2%	1%	3%	8%
Coccoloid Greens	8%	1%	5%	5%	3%	6%
Flagellated Greens	4%	0%	<1%	1%	2%	2%
Filamentous Blue-Greens	3%	1%	8%	6%	6%	5%
Coccoloid Blue-Greens	<1%	1%	<1%	<1%	<1%	1%

2

NUMBER OF DIATOM SPECIES OBSERVED

31	28	18	20	23	34
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(CONTINUED)

TABLE 2
(continued)

FOUR MOST PROMINANT DIATOMS

<u>BR-1</u>	<u>BR-2 5</u>	<u>BR-3</u>	<u>BR-4</u>	<u>BR-5</u>	<u>BR-6</u>
<u>Navicula</u> <u>cryptocephala</u> (25%)	<u>Cymbella</u> <u>ventricosa</u> (49%)	<u>Cymbella</u> <u>ventricosa</u> (59%)	<u>Nitzschia</u> <u>palea</u> (54%)	<u>Achnanthes</u> <u>lanceolata</u> (30%)	<u>Nitzschia</u> <u>palea</u> (16%)
<u>Amphipleura</u> <u>pellucida</u> (11%)	<u>Synedra</u> <u>ulna</u> (11%)	<u>Achnanthes</u> <u>minutissima</u> (10%)	<u>Achnanthes</u> <u>lanceolata</u> (9%)	<u>Nitzschia</u> <u>palea</u> (11%)	<u>Synedra</u> <u>ulna</u> (13%)
<u>Nitzschia</u> <u>palea</u> (10%)	<u>Cymbella</u> <u>turgida</u> (10%)	<u>Navicula</u> <u>cryptocephala</u> (8%)	<u>Achnanthes</u> <u>minutissima</u> (5%)	<u>Cymbella</u> <u>ventricosa</u> (10%)	<u>Melosira</u> <u>varians</u> (11%)
<u>Synedra</u> <u>ulna</u> (10%)	<u>Cymbella</u> <u>prostrata</u> (4%)	<u>Cymbella</u> <u>undet sp</u> (6%)	<u>Cymbella</u> <u>turgida</u> (5%)	<u>Cyclotella</u> <u>meneghiniana</u> (8%)	<u>Gomphonema</u> <u>olivaceum</u> (8%) & <u>Navicula</u> <u>cryptocephala</u> (8%)

TABLE 3

MACROBENTHOS DATA FROM ARTIFICIAL SUBSTRATES

	<u>BR-1</u>	<u>BR-2 5</u>	<u>BR-3</u>	<u>BR-4</u>	<u>BR-5</u>	<u>BR-6</u>
Taxa	20	24	23	22	26	32
No Indiv /Ft ² (M ²)	236(2546)	288(3100)	710(7646)	417(4492)	440(4738)	595(6408)

RELATIVE ABUNDANCE

Diptera	94%	97%	98%	97%	92%	93%
<u>Tanytarsus</u> spp	76%	46%	41%	49%	70%	68%
Other midges	18%	46%	56%	41%	20%	25%
Other diptera	0%	5%	1%	7%	2%	0%
Trichoptera	2%	<1%	1%	3%	1%	<1%
Coleoptera	<1%	0%	<1%	3%	<1%	<1%
Ephemeroptera	2%	<1%	0%	0%	6%	5%
Odonata	<1%	2%	0%	<1%	<1%	0%
Crustacea	0%	0%	0%	0%	0%	0%
Oligochaeta	0%	0%	0%	2%	<1%	0%
Others	<1%	<1%	0%	<1%	0%	<1%

TABLE 4

MACROBENTHOS DATA FROM NATURAL SUBSTRATES

	<u>BR-5</u>		<u>BR-9</u>	
	<u>quan</u>	<u>qual</u>	<u>quan</u>	<u>qual</u>
Taxa	12	28	23	32
No Indiv /Ft ² (M ²)	19 (204)		282 (3040)	

RELATIVE ABUNDANCE

Diptera	39%	65%	45%	46%
<i>Tanytarsus</i> spp	13%	25%	40%	21%
other midges	19%	35%	1%	21%
other dipterans	7%	5%	4%	4%
Trichoptera	50%	23%	45%	6%
Coleoptera	5%	1%	1%	1%
Ephemeroptera	5%	10%	7%	46%
Odonata	0%	<1%	0%	<1%
Crustacea	0%	0%	<1%	1%
Oligochaeta	0%	0%	2%	1%
Others	0%	1%	1%	1%

TABLE 5

Relative Abundance of Big River Phyto-periphyton from Natural Substrates

	<u>BR-5</u>	<u>BR-9</u>
Diatoms	72%	69%
Filamentous Greens	3%	2%
Cocoid Greens	4%	14%
Filamentous Blue-Greens	20%	12%
Cocoid Blue-Greens	<1%	<1%
Other Groups	0%	0%

Four Most Prominant Diatoms from Each Station

<u>BR-5</u>	<u>BR-9</u>
<u>Nitzschia amphibia</u> (40%)	<u>Cymbella ventricosa</u> (47%)
<u>Nitzschia fonticola</u> (8%)	<u>Nitzschia amphibia</u> (12%)
<u>Nitzschia palea</u> (7%)	<u>Gomphonema olivaceum</u> (8%)
<u>Achnanthes lanceolata</u> (7%)	<u>Synedra ulna</u> (8%)

TABLE 5

Relative Abundance of Big River Phyto-periphyton from Natural Substrates

	<u>BR-5</u>	<u>BR-9</u>
Diatoms	72%	69%
Filamentous Greens	3%	2%
Coccoloid Greens	4%	14%
Filamentous Blue-Greens	20%	12%
Coccoloid Blue-Greens	<1%	<1%
Other Groups	0%	0%

Four Most Prominent Diatoms from Each Station

<u>BR-5</u>	<u>BR-9</u>
<u>Nitzschia amphibia</u> (40%)	<u>Cymbella ventricosa</u> (47%)
<u>Nitzschia fonticola</u> (8%)	<u>Nitzschia amphibia</u> (12%)
<u>Nitzschia palea</u> (7%)	<u>Gomphonema olivaceum</u> (8%)
<u>Achnanthes lanceolata</u> (7%)	<u>Synedra ulna</u> (8%)

TABLE 6
BIG RIVER CHEMICAL DATA

	June 2, 1977			August 24, 1977		
	BR-1	BR-3	BR-5	BR-1	BR-3	BR-5
Temperature (°C)	23 0	22 0	23 0	25 0	22 0	22 4
pH	7 8	8 0	8 0	7 8	8 0	7 8
Conductivity (μMHOS at 25°C)	--	--	--	385	400	480
Total Hardness (as CaCO ₃)	--	--	--	171	176	202
Organic Nitrogen	--	--	--	<0 50	<0 50	<0 50
Total Ammonia	<0 04	<0 04	<0 04	0 32	0 06	0 16
Nitrites and Nitrates	<0 04	0 17	0 07	0 04	0 40	0 16
Total Soluble Phosphorus (OP ₄ ⁻)	--	--	--	<0 04	<0 04	0 05
Total Soluble Carbon	--	--	--	44	40	50
Aluminum	--	--	--	374	296	248
Arsenic	--	--	--	021	009	011
Barium	180	150	120	148	136	125
Beryllium	--	--	--	< 000	< 000	< 000
Boron	--	--	--	06	08	07
Cadmium	--	--	--	005	005	004
Calcium	--	--	--	38	41	48
Chromium	--	--	--	012	008	019
Copper	< 005	< 005	< 005	004	009	006
Iron, Total				344	416	307
Iron, Dissolved				046	014	105
* Lead	< 005	028	080	024	137	075

Table 6 contd

Magnesium	27	26	28	25	25	27
Manganese, Total	--	--	--	088	082	114
Manganese, Dissolved	--	--	--	016	042	074
Mercury	--	--	--	< 0002	< 0002	< 0002
Nickel	< 01	< 01	< 01	002	006	008
Sodium	--	--	--	2 7	2 7	6 41
* Zinc	030	203	044	024	192	043

All values, unless otherwise indicated, are expressed as mg/l

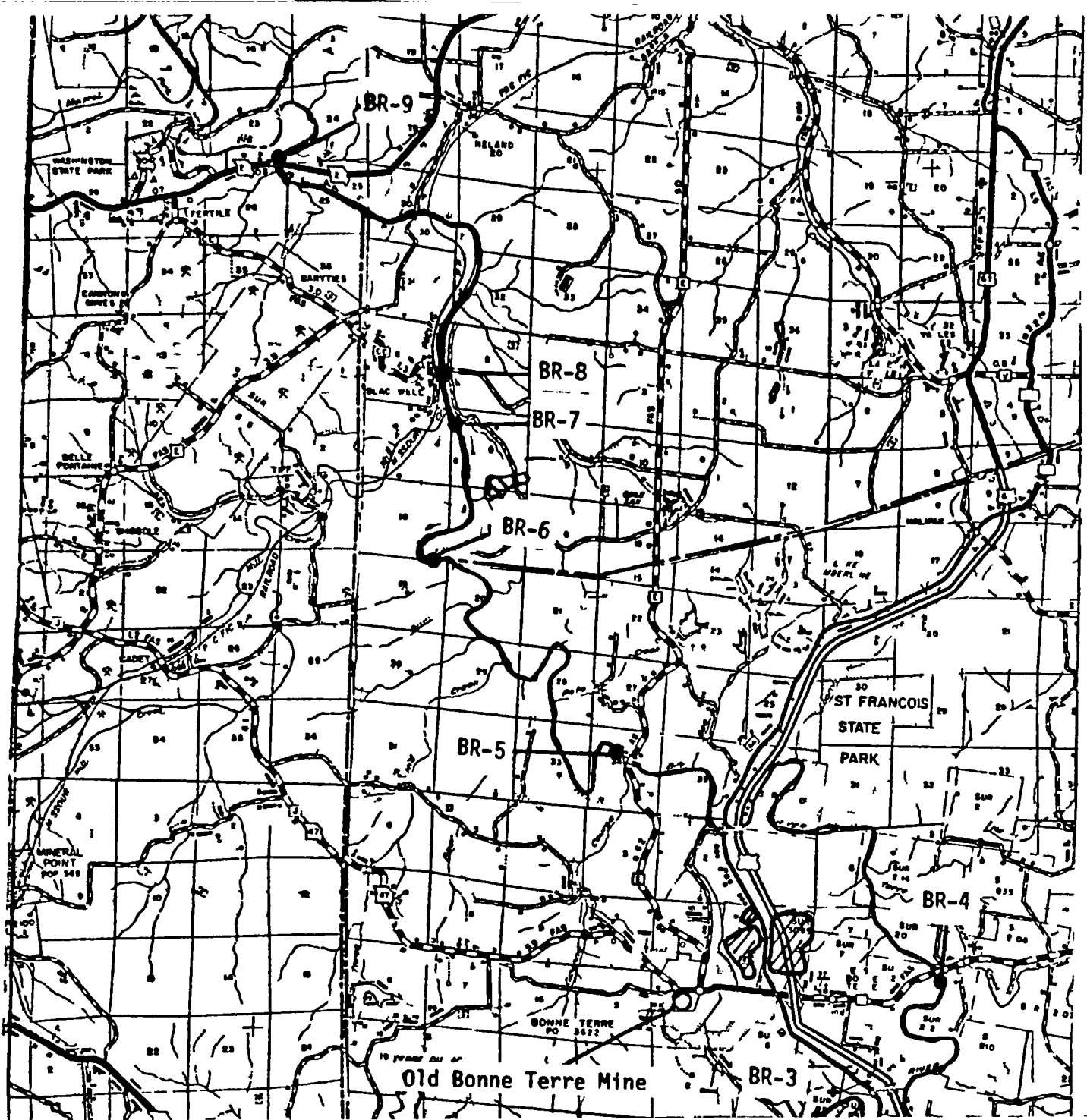


Figure 1
STUDY AREA LOCATION MAP

